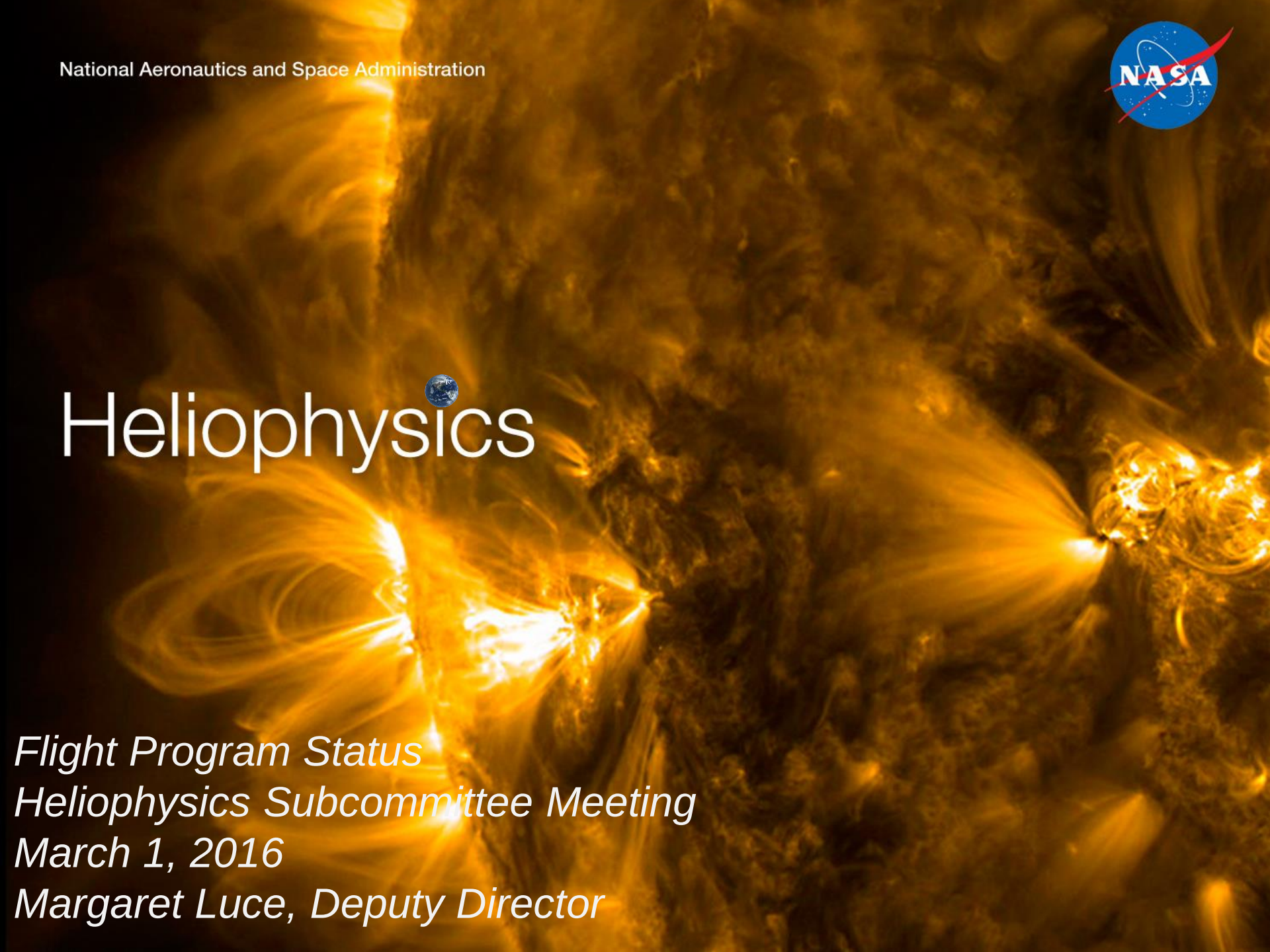
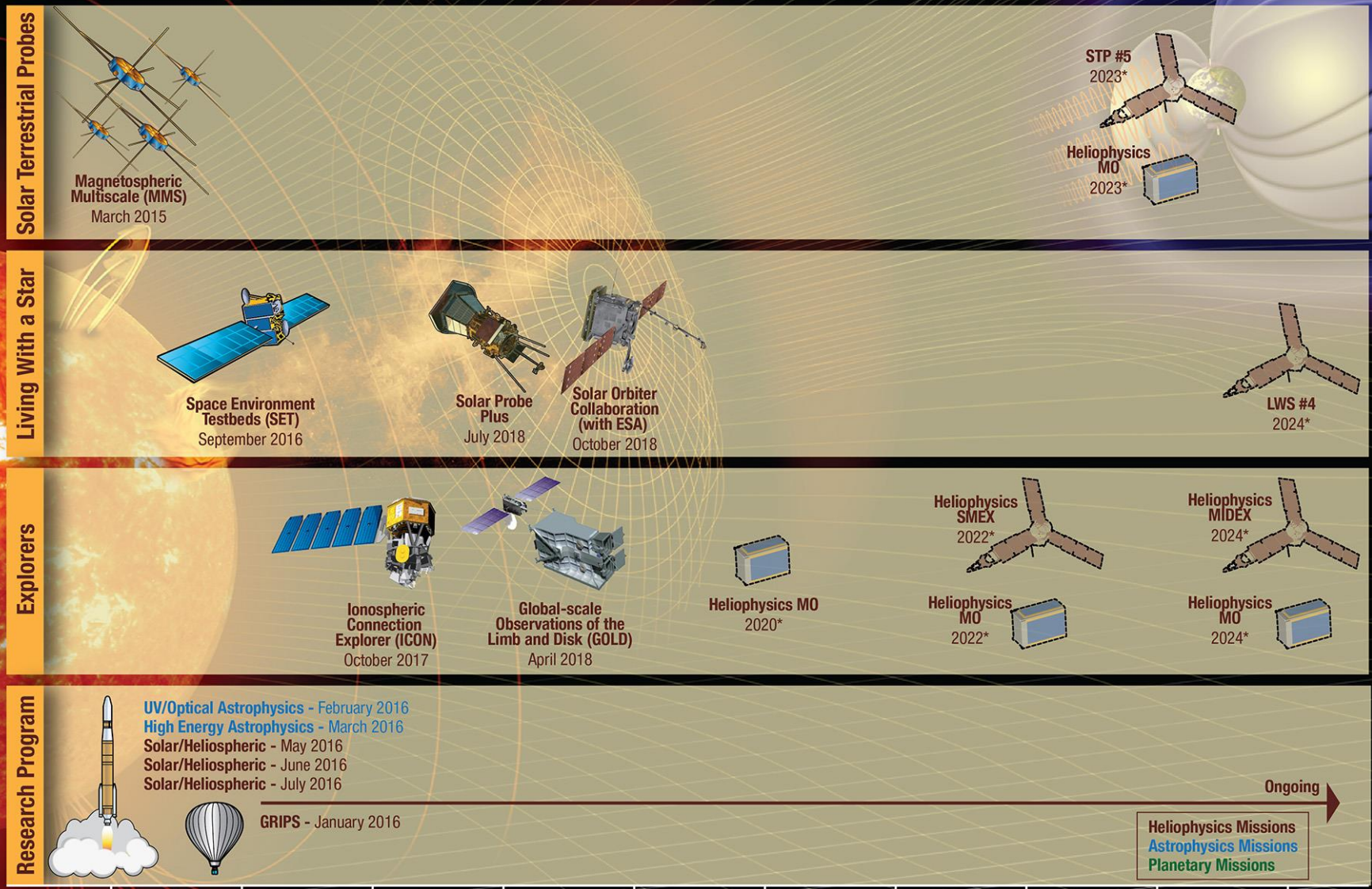
National Aeronautics and Space Administration



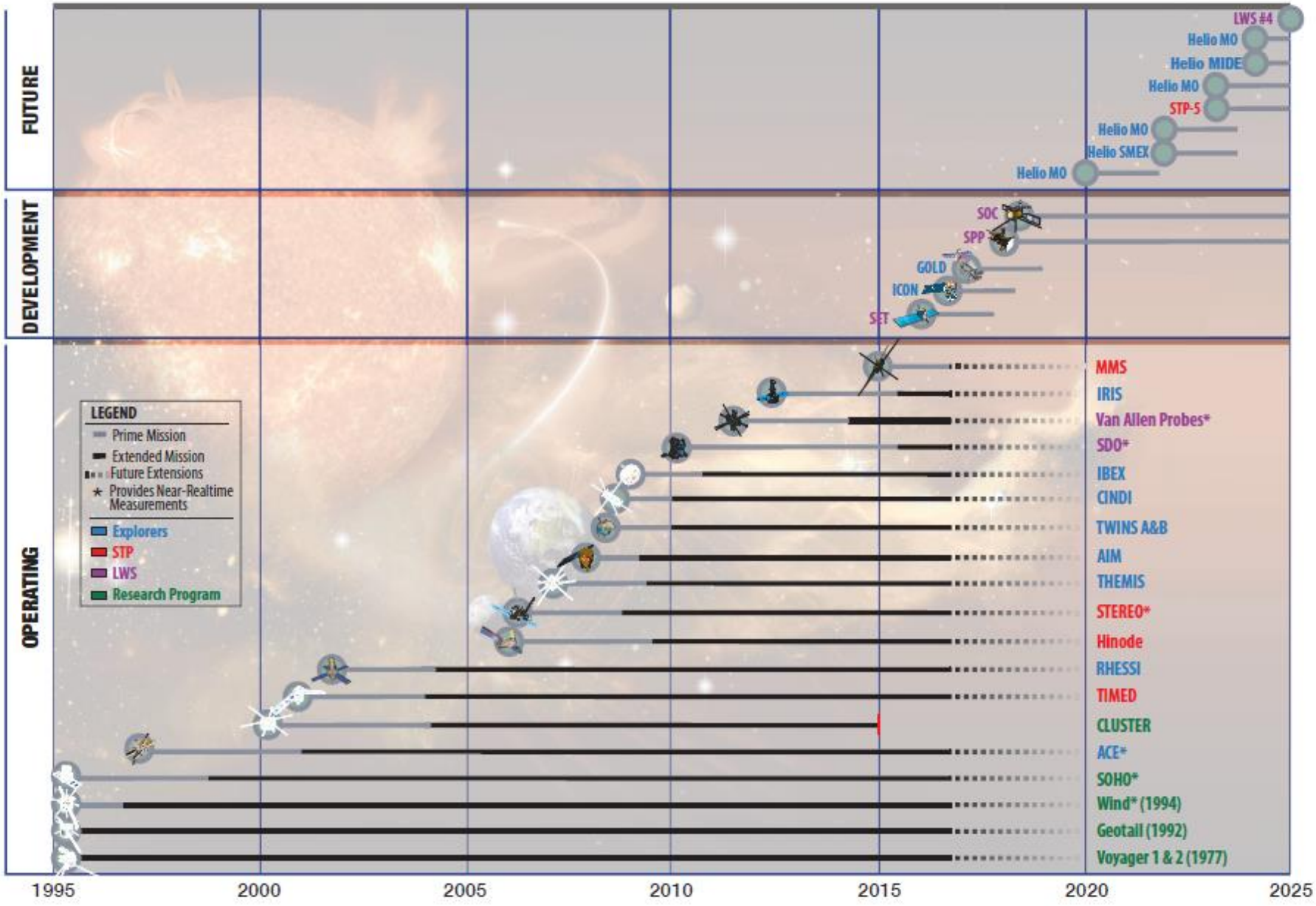
Heliophysics

Flight Program Status
Heliophysics Subcommittee Meeting
March 1, 2016
Margaret Luce, Deputy Director

Heliophysics Program 2015-2024



Heliophysics Mission Timeline 1995-202



Magnetospheric Multiscale (MMS) Mission

Description: MMS is a Solar Terrestrial Probes mission with four identically instrumented spacecraft that use Earth's magnetosphere as a laboratory to study the microphysics of magnetic reconnection.

Launched 3/12/2015, the MMS constellation's orbit, spin rates and attitudes are nominal, and initial science results are excellent.

Recent Accomplishments:

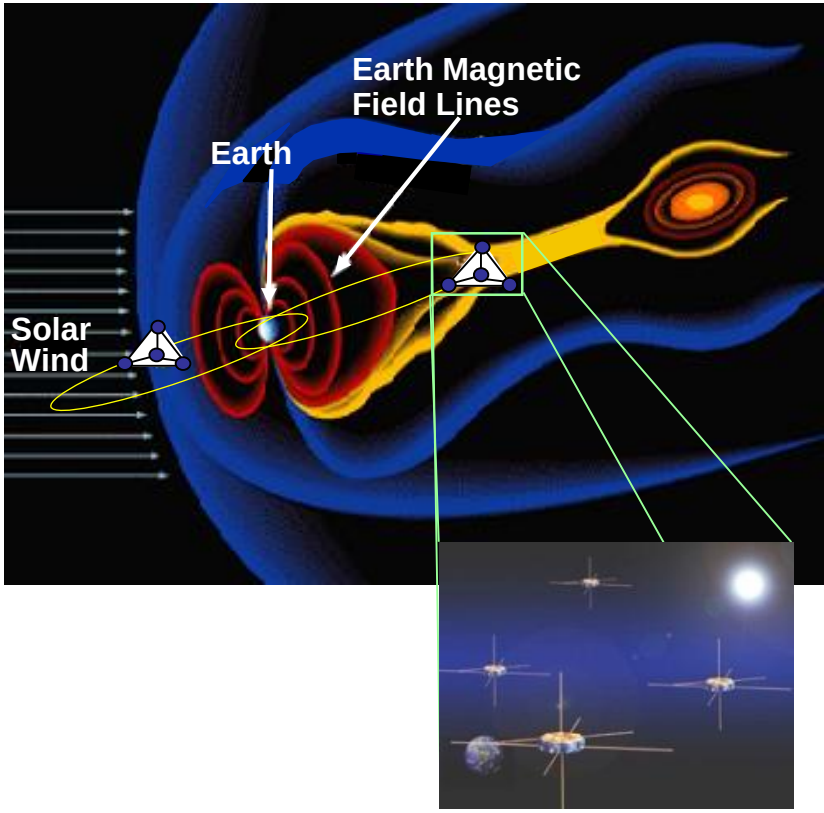
- March 1 release of data (Sep 15 – Jan 16) with monthly updates.
- March 8 completion of Phase 1a, begin Phase 1x.
- GRL special issue submissions due March 15.

Planning Items:

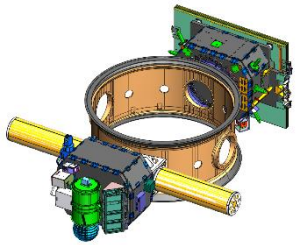
- Phase 1x science ops for Van Allen Probes conjunctions & dipolarization front campaign.
- Orbit will be raised for Phase 2 (Magnetotail) from 12 Re to 25 Re (Jan 31 – 26 Sep 2017).

Watch Items/Concerns:

- There have been a number of Star Tracker reboots on all 4 of the satellites. The vendor (Danish Tech Univ) is working with the project on the issue. The reboots have all been resolved by the on-board autonomy with minimal data loss.



LWS Space Environment Testbeds (SET)-1



Launch Information:

- **Spacecraft:** AFRL Deployable Structures Experiment (DSX)
- **Launch Vehicle**: SpaceX Falcon Heavy
- **Date**: March 2017
- **Site**: Cape Canaveral
- **Orbit**: 6000 x 12,000 km, 45 degree inclination MEO

Description:
Space Environment Testbeds (SET) improves the engineering approach to accommodate and/or mitigate the effects of solar variability on spacecraft design and operations by: 1) collecting data in space to develop a physics-based understanding of response of spacecraft materials, components, & sensors/detectors to space environments; 2) collecting data in space to validate new & existing ground test protocols for the effects of solar variability on emerging technologies; and 3) developing & validating engineering environment models, tools, & databases for spacecraft design & operations.

Accomplishments:

- All flight hardware has been delivered, including the separation system for the DSX secondary payload.
- EMI / EMC tests are complete and showed no problems.
- Vibe tests completed for payload module.

Upcoming Milestones:

- TVAC tests planned for March-April 2016.
- Activities scheduled for FY16 include work with the separation system, mission readiness review (MRR), and 4 mission rehearsals.

Watch Items/Concerns:

- None

Ionospheric Connection Explorer (ICON)

Description: ICON will explore the boundary between Earth and space to understand the physical connection between our world and our space environment. ICON will launch on a Pegasus XL launching from Kwajalein Atoll in October 2017. The spacecraft will be placed in a LEO Orbit at 575 km with a 27° inclination. The payload consists of four instruments, MIGHTI (NRL) – neutral wind measurements; IVM (UT Dallas) – in situ ion velocities; and FUV & EUV imaging UV spectrographs (UC Berkeley) – ion density.

Recent Accomplishments:

- MIGHTI: MIGHTI-A and –B integrated onto the Payload Interface Plate (PIP)
- FUV: Delivered for integration
- EUV: Delivered for integration
- IVM: IVM-A delivered for integration to the PIP. IVM-B ready for shipment to the PIP for integration.
- ICP: Testing completed; Delta Pre-Ship Review scheduled for 3/10 following FPGA upgrade scheduled for this week.

Upcoming Milestones/Events:

- SIR – June 2016
- KDP-D – July 2016
- PER – August 2016
- LRD – October 2017

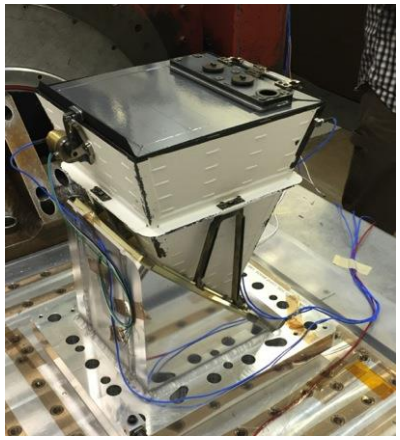
Issues/Concerns:

- IMAU: Failure to power up after integration; LVPS instability was identified as the cause of the improper power ramp. Three (3) boards with stressed parts are in rework; in addition a zener diode snubber is being added to the low voltage power supply. Delivery is expected on 4/5/16.

MIGHTI A & B installed on top deck of PIP

GOLD
- Global Observations of the Limb And Disk -

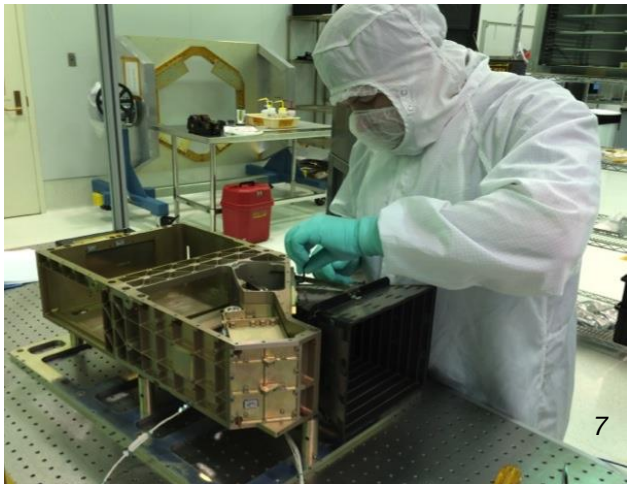
Description: GOLD is an Explorer Program Mission of Opportunity that will provide the first simultaneous measurements of temperatures and composition in Earth's thermosphere and ionosphere on a global scale. GOLD will fly a UV imaging spectrograph as a hosted payload on a commercial communications spacecraft in geostationary orbit.


Aperture cover mechanism

Recent Accomplishments:

- Collimator mirror assemblies have been successfully installed into both instrument channel housings and alignments are in work.
- All electronics boards have successfully completed bench testing and fit checked in the GOLD electronics housing.
- Lightshade assembly complete and ready for integration
- FM1 detector is at UCB/SSL for refurbishment, while FM2 is supporting both Channel 1 and then Channel 2 alignment and functionality testing.

Channel 1 Assembly



Upcoming Milestones/Events:

- PER – May 2016
- PSR – October 2016
- LRD – April 2018

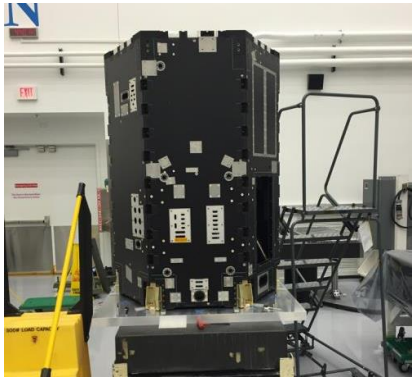
Issues/Concerns:

- Quantum efficiency of the detector on FM1 was reduced after its first scrub; contamination in the process caused it to be returned to UCB/SSL for micro-channel plate replacements and refurbishment.

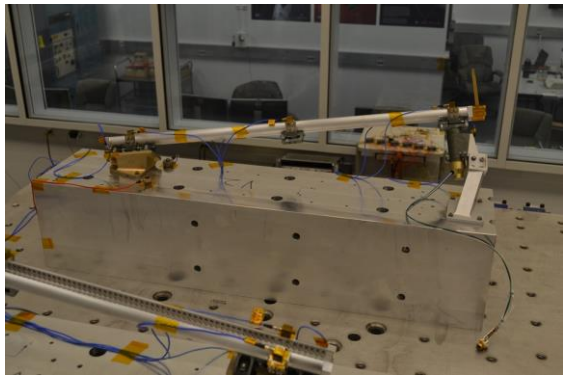
Solar Probe Plus (SPP)

Description

Spacecraft in a highly eccentric elliptical orbit with a minimum perihelion of 9.9 Solar Radii (~4.3 million miles). Employs a combination of in-situ measurements and imaging to achieve the mission's primary scientific goal: to understand how the Sun's corona is heated and how the solar wind is accelerated.



Flight Spacecraft Structure



FIELDS Clamshell Testing

Upcoming Milestones

- SIR – May 2016
- PER – October 2017
- PSR – March 2018
- LRD – July 2018

Recent Accomplishments

- MOR – Nov 2015
- FIELDS whip antenna: Testing and analysis of EM antenna and clam shell successfully completed, retiring this risk.
- Launch Vehicle: Successfully completed the Mission Specific Requirements Review
- Cooling System: Completed top and bottom manifold assembly (welding) and inspection
- Mag Boom: Successfully completed EM boom thermal vacuum pop-n-catch test
- Structure: Flight structure shipped to Aerojet for installation of propulsion subsystem

Watch Items/Concerns

- Late delivery of first Solar Array platen could impact schedule reserve.
- Truss Structure Assembly (TSA) developed a weld crack during vibe test; FRB initiated.

Solar Orbiter Collaboration (SOC)

Description: Will use a unique combination of measurements: *In situ* measurements will be used alongside remote sensing, close to the sun (~.3 AU), to relate these measurements back to their source regions and structures on the sun's surface. Operates both in and out of the ecliptic plane. Measures solar wind plasma, fields, waves and energetic particles close enough to the Sun to ensure that they are still relatively pristine.

Recent Accomplishments:

- Heavy Ion Sensor (HIS) instrument Post Acceleration (PAC) isolator completed peer review, fabrication and testing beginning.
- Solar Orbiter Heliospheric Imager (SoloHI):
  - Thermal correlation successfully completed; no requirement for additional heaters or heater resizing.
  - Stray light testing complete; results indicate science requirements should be met.

Upcoming Milestones:

• Mission Delta-CDR	
• Kick-Off/Close-Out	Apr/Jun 2016
• SoloHI PER	Apr 2016
• HIS PER	Jun 2016
• SoloHI PSR	Jun 2016
• HIS PSR	Sep 2016
• LRD	Oct 2018

HIS Heat Shield Assembly - Completed

Watch Items/Concerns:

- Schedule risk (spacecraft) to LRD
- Completion of IRAP High Voltage Power Supply delayed at IRAP, impacting the HIS delivery.

Heliophysics Missions in Formulation & Development
Director's Assessment – February 2016

Project	Overall previous months				This Month					Comments
	-4	-3	-2	-1	O	T	C	S	P	
Development										
EX-ICON Oct 2017	G	G	G	G	G	Y	G	G	G	ICON Master Avionic Unit (IMAU) – failed to power up properly when integrated into spacecraft; root cause is LVPS instability.
EX-GOLD Apr 2018	G	G	G	G	G	G	G	G	G	Making good progress; FM1 detector returned to vendor (UCB/SSL) as a result of contamination.
LWS-SPP Jul 2018	G	G	G	G	G	Y	G	G	G	Loads on FIELDS Whip antenna being addressed.
LWS-SOC Oct 2018	G	G	G	G	G	Y	G	G	Y	HVPS delivery expected in March; HIS schedule can accommodate. LRD schedule margin assessment ongoing. ESA Delta CDR planned to complete in June.
LWS – SET Mar 2017	G	G	G	G	G	G	G	G	G	LRD delayed from Sept 2016 to March 2017.

T: Technical, S: Schedule, P: Programmatic,
C: $ resources, O: overall

On plan, adequate Margin

Problems, working to resolve within planned Margin

Problems, not enough margin to recover

Status of HPD Operating Missions

Mission	Launch	Phase	Extension to (*)	M-3	M-2	M-1	Cur. M.	Remarks
Geotail	7/24/1992	Extended	12/31/2016					
STEREO	10/25/2006	Extended	9/30/2018					Still no response from B. DSN Cadence moves to 1 per 2wks 3/11.
THEMIS+Artemis	2/17/2007	Extended	9/30/2018					D lost a total of 29.8 h on 12/15&1/2: E lost 2.4h on 12/26.
AIM	4/25/2007	Extended	9/30/2018					
Hinode	9/23/2006	Extended	9/30/2018					
ACE	8/27/1997	Extended	9/30/2018					
RHESSI	2/5/2002	Extended	9/30/2018					
SOHO	12/2/1995	Extended	9/30/2018					
TIMED	12/7/2001	Extended	9/30/2018					
Voyager 1 + 2	8/20/1977	Extended	9/30/2018					
TWINS A + B	6/2006 & 3/2008	Extended	9/30/2018					
CINDI:C/NOFS	4/16/2008	Extended	12/31/2015					Phase F plan in-hand. Direction forthcoming.
IBEX	10/19/2008	Extended	9/30/2018					Star Tracker issue on 2/7; S/C recovered and in full science mode; s/w update expected in March.
Wind	11/1/1994	Extended	9/30/2018					SE on 1/29: recovered in 1 hr.
SDO	2/11/2010	Extended	9/30/2018					High winds on 2/1 closed SDO1&2: 117 min science lost.
Van Allen	8/30/2012	Extended	9/30/2018					Snow on APL antenna on 2/1 caused minor loss of EMFISIS data.
IRIS	6/27/2013	Extended	9/30/2018					
MMS	3/12/2015	Prime	9/1/2017					MMS3 star tracker reboot on 2/1: no data lost. Vendor called.

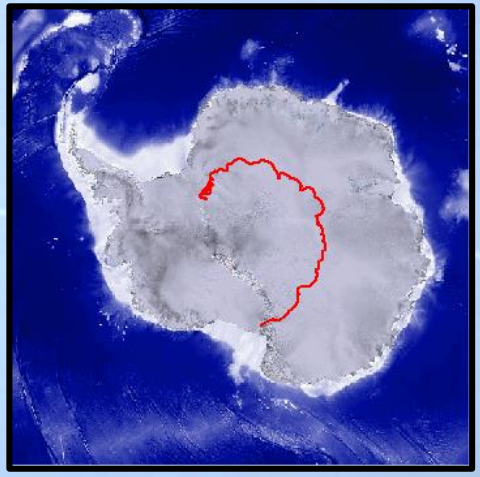
(*) Extended mission end dates subject to upcoming Senior Revie (+) Terminates at date.

Mission proceeding to meet science requirements

Area of concern - possible reduction in capability

Heliophysics Flight Program Highlights

Balloon Missions - Gamma-Ray Imager/Polarimeter for Solar flares (GRIPS)

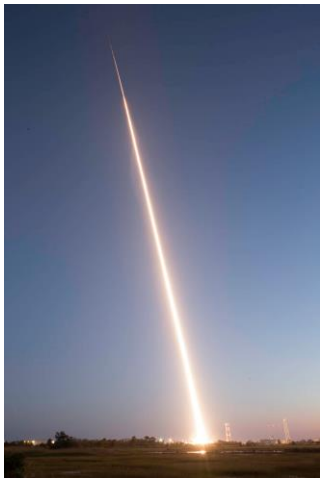


- PI: Pascal Saint-Hilaire, UCB/SSL
- Designed to observe flare gamma-ray/hard X-ray emission with an unparalleled angular resolution at gamma-ray energies (12.5 arcsec)
- Launched: 19 January 2016 from McMurdo Station, Antarctica

- Flight lasted 11 days, 19 hours, 50 minutes; Mission (Flight 668N) was successfully terminated over East Antarctica to expedite recovery of high priority items.
- 21 C-class flares occurred, with the largest at C9.6, with concurrent RHESSI observations
- Radiation-belt precipitation was observed
- Data vaults successfully recovered

Recent Sounding Rocket Launches

- **Hesh Mission – Successful launch from Wallops Island, VA on October 7, 2015**
  - The first flight of the Black Brant Mk 4 was successfully conducted.
  - While the primary purpose of this flight was to verify the performance of the new motor, a payload with technology development experiments were also onboard this mission.



Wallops Island, VA

- **Lessard Mission – Successful launch from Andøya Space Center on December 13, 2015**
  - A University of New Hampshire investigation, Rocket Experiment for Neutral Upwelling II (RENU) was designed to transit the magnetospheric cusp region during a neutral upwelling event.
  - The Black Brant XII-A rocket was equipped with a suite of instruments that build on previous observations of neutral upwelling in the thermosphere.

Andøya Rocket Range, Norway

Recent Sounding Rocket Launches

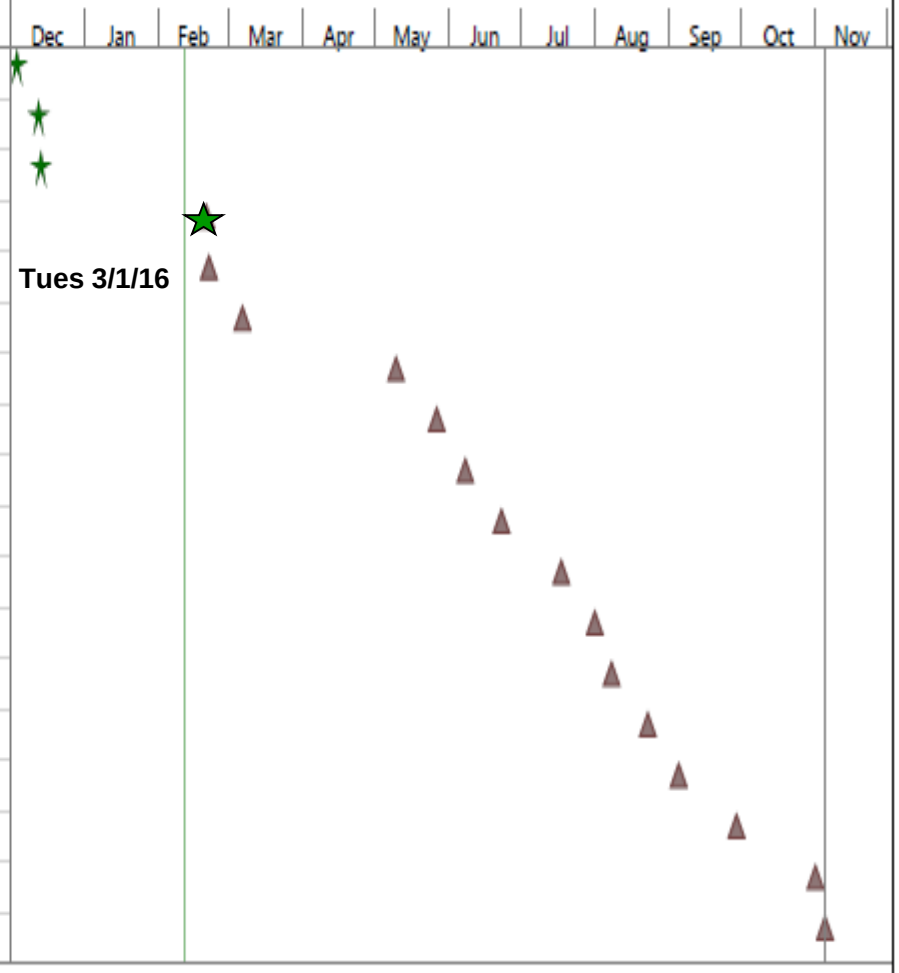
- **LaBelle Mission – Launch from Andøya Space Center on November 30, 2015**
  - The Dartmouth College experiment was designed to establish the role and nature of Alfven wave acceleration in the cusp and discover the causes of the observed differences in the Langmuir waves in the cusp versus the night side.
  - This mission experienced launch vehicle anomaly and no science data was obtained. A possible re-flight is under assessment.

LaBelle payload and Nihka 4th stage motor moving to launch pad - Norway

Sounding Rockets Schedule

NSRP Mission Manifest Dec 2015 Nov 2016 — Updated: Feb 12, 2016

Flag Fields	Mission Title	Launch Date
.....BB	GALEAZZI DXL-2 WS	Fri 12/4/15
.....BB	LESSARD RENU 2 NOR	Sun 12/13/15
.....BB	MCCANDLISS FORTIS WS	Mon 12/14/15
.....BB	FRANCE CHESS-2 WS	Sun 2/21/16
.....	MILLINER MUSIC WI	~~Mon 2/22/16~~ → Tues 3/1/16
.....	DELEON WI	Mon 3/7/16
R.....	CHRISLEY ZOMBIE WS	Tue 5/10/16
.....BB	WOODS SDO EVE WS	Fri 5/27/16
.....BB	TUN BELTRAN HERSCHEL WS	Wed 6/8/16
.S.....	KOEHLER ROCKON - RockSAT-C WI	Thu 6/23/16
.....BB	CIRTAIN HiC WS	Mon 7/18/16
R.....	CLARK SHARPIE WI	Mon 8/1/16
.S.....	KOEHLER RockSAT-X WI	Mon 8/8/16
.....BB	HASSLER RAISE WS	Tue 8/23/16
.....	MILLINER WI	Mon 9/5/16
R.....	CLARK SHARPIE TBD	Thu 9/29/16
.....BB	FIGUEROA MICRO-X WS	Tue 11/1/16
.....BB	HESH SUBTEC 7 WI	Sat 11/5/16



Acronym List

- ABC – Agency Baseline Commitment
- ACE – Advanced Composition Explorer
- AFRL – Air Force Research Laboratory
- AIM – Aeronomy of Ice in the Mesosphere
- AO – Announcement of Opportunity
- BARREL – Balloon Array for Radiation Relativistic Electron Losses
- CINDI – Coupled Ion Neutral Dynamic Investigation
- CDR – Critical Design Review
- EM – Engineering Model
- EMC – Electromagnetic Compatibility
- EMI – Electromagnetic Interference
- EUV – Extreme Ultraviolet
- FM – Flight Model
- FPGA – Field Programmable Gate Array
- FRB – Failure Review Board
- FUV – Far Ultraviolet
- GOLD – Global-scale Observations of the Limb and Disk
- GRIPS -- Gamma-Ray Imager/Polarimeter for Solar flares
- HIS – Heavy Ion Sensor
- HVPS – High Voltage Power Supply
- IBEX – Interstellar Boundary Explorer
- ICON – Ionospheric Connection Explorer
- ICP -- Instrument Control Package
- IMAU -- ICON Master Avionic Unit
- IRAP – Industrial Research Assistance Program
- IRIS – Interface Region Imaging Spectrograph
- IVM -- Ion Velocity Meter
- KDP – Key Decision Point
- LCC – Life Cycle Cost
- LRD – Launch Readiness Date
- LVPS – Low Voltage Power Supply
- LWS – Living With a Star
- MCP – Micro-Channel Plate
- MEO – Medium Earth Orbit
- MIDEX – Medium-Class Explorer
- MIGHTI -- Michelson Interferometer for Global High resolution Thermospheric Imaging
- MMS – Magnetospheric Multi-Scale
- MoO – Mission of Opportunity
- MOR – Mission Operations Review
- NRA – NASA Research Announcement
- PER – Pre-Environmental Review
- PDR – Preliminary Design Review
- PI – Principal Investigator
- PIP – Payload Interface Plate
- PSR – Pre-Ship Review
- RHESSI – Ramaty High-Energy Solar Spectroscopic Imager
- ROSES – Research Opportunities in Space and Earth Sciences
- SDL – Space Dynamics Laboratory
- SDO – Solar Dynamics Observatory
- SET – Space Environment Testbed
- SIR – System Integration Review
- SMEX – Small Explorer
- SOC – Solar Orbiter Collaboration
- SoloHI -- Solar Orbiter Heliospheric Imager
- SPP – Solar Probe Plus
- STEREO – Solar-Terrestrial Relations Observatory
- STP – Solar Terrestrial Probes
- THEMIS – Time History of Events and Macroscale Interactions during Substorms

Acronym List (Cont'd)

- TIMED – Thermosphere-Ionosphere-Mesosphere Energetics and Dynamics
- TVAC – Thermal Vacuum
- TWINS – Two Wide-Angle Imaging Neutral-Atom Spectrometers
- UCB/SSL – UC Berkeley/Space Sciences Laboratory
- UFE – Unallocated Future Expenses
- VAP – Van Allen Probes